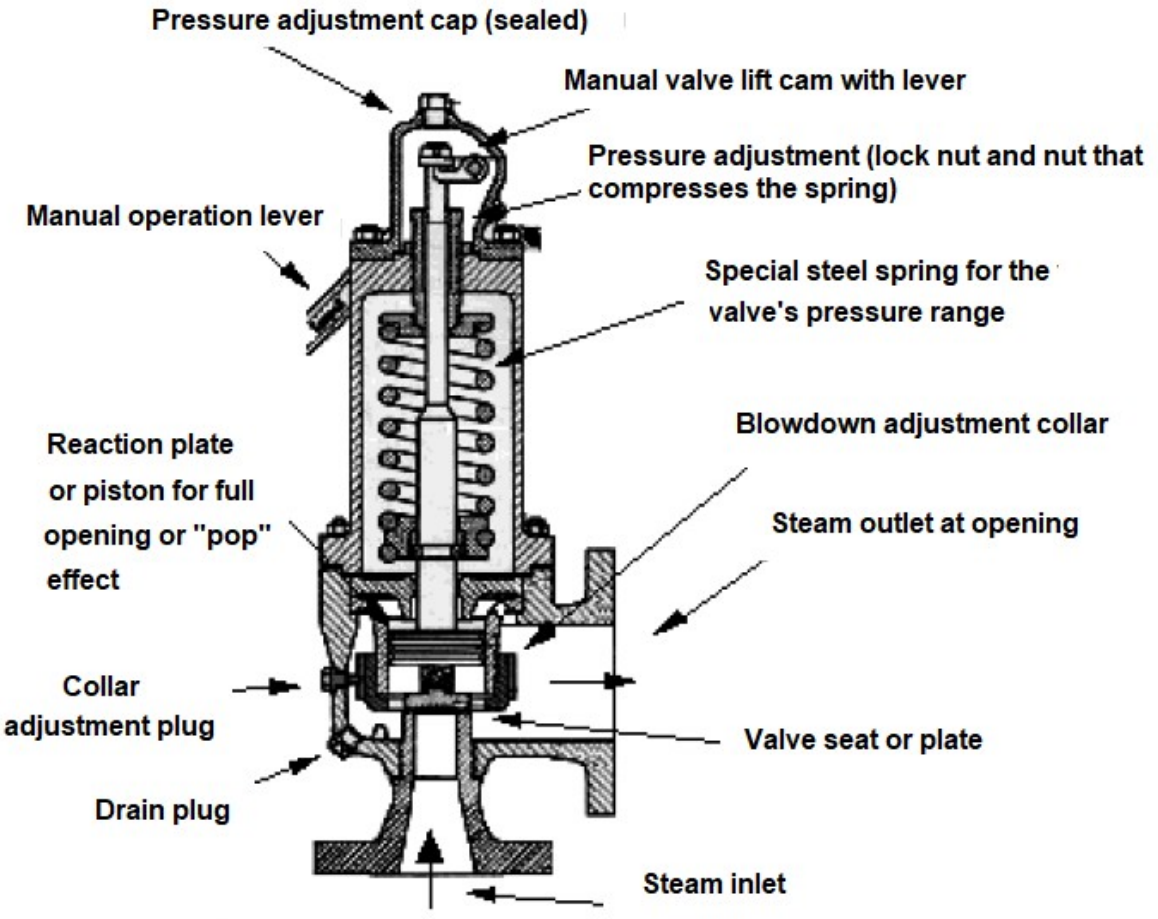
CHAPTER 12: SAFETY VALVES FOR BOILERS.

MINIMUM REQUIREMENTS:

According to American standards, **they must be spring-loaded**.

In Uruguay, safety valves with weights or "counterweights" are not accepted; they are accepted in some European countries, in certain boilers), fully opening (pop effect), close below the opening pressure by a regulated or adjustable percentage (hysteresis or differential closing pressure), and have a lever for testing (weekly, etc.).


Pressure adjustment cap (sealed)
Manual valve lift cam with lever
Pressure adjustment (lock nut and nut that compresses the spring)
Manual operation lever
Special steel spring for the valve's pressure range
Blowdown adjustment collar
Reaction plate or piston for full opening or "pop" effect
Steam outlet at opening
Collar adjustment plug
Valve seat or plate
Drain plug
Steam inlet

These operating conditions for boiler safety valves cause them to open rapidly to full capacity.

This immediate "full opening" is what differentiates a "safety valve" from a "relief valve". The former could be described as having an "all or nothing" opening, while the latter (the relief valve) modulates the percentage of

opening.

This prevents the seats from being scored and allows them to reach their maximum discharge capacity immediately.

This ensures that the pressure does not rise above the regulated level for opening, even if the valve's capacity (its large size) allows it.

However, there is a slight pressure increase between the initial opening pressure and full opening, no more than 3% of the initial pressure.

This results in two types of valves: one that opens immediately ("full bore") and another that requires this overpressure or excess pressure to fully open ("low lift").

Closing below the opening pressure prevents the valve from oscillating or rattling upon closing, ensuring a quick closure (this also prevents the seat from being scratched and leaking, and guarantees that the closure occurs below the maximum design pressure).

The lever allows for testing without needing to raise the pressure to the trigger or trigger pressure (the test is performed when the pressure is close to the maximum working pressure, so the effort required to trigger the valve is minimal; this action keeps the valve mechanisms free from seizing, making it important to perform this test periodically (for example, once a week, at times that do not interfere with steam production).

As mentioned in a previous chapter, but reiterated, safety valves should not be painted, as the paint will inevitably affect their mechanisms and operation.

How can you tell if a valve is actually a boiler safety valve once it's installed, and not just a simple relief valve?

Activate the valves one by one, gradually increasing the pressure and taking care not to exceed the maximum permissible working pressure (maximum design pressure or "ringing pressure").

In this case, the valve should open fully (like pulling a cork out of a bottle) and close at a lower pressure (turn off the

burner).

If you do not want to raise the pressure above the pressure regulated by the automatic pressure switches, the test can be performed by using the lever: when the maximum working pressure is reached (boiler pressure cutoff).

Pull the lever; the valve will open easily and fully and should close below the opening pressure.

If the valves do not have a test lever, they are already disqualified as boiler safety valves.

These valves are **relief valves for steam, gases, or liquids** (they do not have full opening or differential closing).

When purchasing a boiler safety valve: it generally comes certified by the manufacturer, who has used the original standards.

It is advisable to request the accompanying brochures to check if the valve is approved as a boiler safety valve, and if it has its capacity, opening pressure range, maximum temperature, etc., clearly marked.

This is also important because the materials must be of a quality that prevents the valves from seizing due to corrosion or the seats from wearing down.

The springs are important in terms of material quality (ensuring they do not weaken over time and with temperature) and the range in which they can be used (an overly compressed spring loses travel or length, which reduces the effectiveness of the opening).

For this reason, do not use valves with springs outside the range recommended by the manufacturer. Never replace springs without using those of the quality and characteristics specified by the valve manufacturer.

SAFETY VALVE CAPACITY

It is clear that, from a practical standpoint, the safety valves of a boiler must be capable of releasing at least all the steam generated

in the boiler under the most demanding conditions.

For example;
the **burner's automatic high-pressure shut-off could fail, and simultaneously, the mechanism regulating maximum combustion—the high-pressure protection switch—would not shut off**. In a wood-fired boiler, all air vents would open and the induced draft would be set to maximum, or in a fuel-oil boiler, the fuel inlet would be set to maximum along with the necessary air. The only limit to this maximum is the surface area for heat transfer from combustion to the boiler water and the condition of that surface (fouling).

Another question is what happens if a boiler safety valve becomes stuck or seized (remember that if the combustion limiting mechanisms fail, the only control over the pressure limit is the safety valves; if the only valve we have fails, we obviously run significant risks).

Some standards (ASME, USA) specify the following regarding the capacity of safety valves:

1- All boilers with a heating surface area greater than 500 square feet (approximately 46 m^2, or 500 kW of power) must have two or more safety valves.

2- The capacity of the safety valves must not allow the pressure to rise above 6% of the maximum allowable working pressure (formerly called the "ringing" pressure) and above 6% of the valve opening pressure.

In German standards, instead of 6%, a 10% excess pressure over the maximum working (design) pressure is permitted.

Similarly, the blowdown pressure in U.S. standards is a maximum of 6% below the opening pressure, while in German standards it is 10%.

However, this blowdown differential (hysteresis) cannot be less than 1 PSI or 2 PSI, depending on the valve's pressure rating, to ensure a tight seal, as described below.

What must be clear is that the closure must be "smooth" (quick) and not "chattering," since not only can the seat be scratched or the valve leak, but it can also cause the valve to oscillate and chatter, potentially leading to its destruction.

The only solution is to gradually increase the closing pressure differential until the valve closes correctly; in some cases, this differential may need to be greater than previously indicated.

This differential adjustment (hysteresis) should supposedly be factory-set and sealed. DO NOT TOUCH IT

It must be clear that the maximum permissible working pressure (boiler design pressure) is not the actual working pressure of the steam supply to the plant.

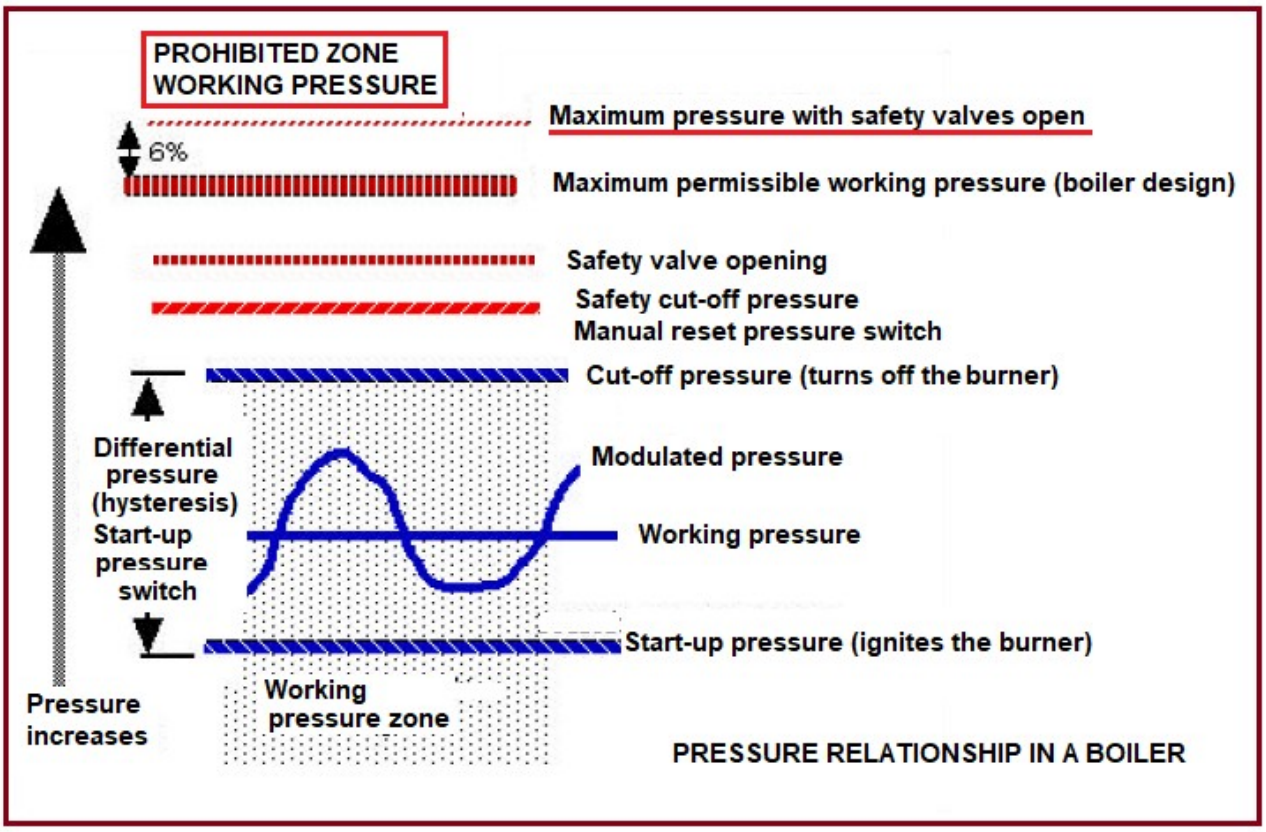
With the safety valves open, under no circumstances (while the boiler is steaming) should the pressure ever exceed 6% (or 10% according to the German standard).

Therefore, the actual operating pressure in the plant must be below the maximum permissible operating pressure (boiler design).

This pressure must be at a level that allows the burner to modulate with the pressure, and above this modulation, a high-pressure combustion cutoff point must be reached (in case the modulating burner, for any reason, allows the pressure to rise to the cutoff limit).

Only above this cutoff pressure will the first safety valve open.

This value may be below the maximum permissible operating pressure (boiler design pressure), but never above it. The pressure cannot be allowed to rise more than 6% (10% in German standards) with all safety valves open.


PROHIBITED ZONE
WORKING PRESSURE
Maximum pressure with safety valves open
6%
Maximum permissible working pressure (boiler design)
Safety valve opening
Safety cut-off pressure
Manual reset pressure switch
Cut-off pressure (turns off the burner)
Differential pressure (hysteresis)
Start-up pressure switch
Modulated pressure
Working pressure
Start-up pressure (ignites the burner)
Working pressure zone
Pressure increases
PRESSURE RELATIONSHIP IN A BOILER

Between the high-pressure cutoff switch and the opening pressure of the first safety valve, it is advisable to have a maximum safety cutoff pressure switch (with a special pressure switch that opens the circuit and shuts off the burner if the high-pressure cutoff switch fails, but which has the particularity that the circuit does not "close" again unless the boiler operator performs a "reset" or a manual reset button.

In this way, the boiler operator is notified that there is a fault in the pressure control system, meaning that the burner is not shutting off at its normal cutoff pressure, and therefore can investigate the problem before restarting.

Let's look at an example:

We have a boiler whose working pressure should be 10 kg/cm². It's clear that if the burner modulation is continuous, there will be a variation in the regulation that could be approximately plus or minus 0.3 kg/cm² (from 9.7 kg/cm² to 10.3 kg/cm²).

Therefore, there will be a start (and cut-off) pressure switch that could be set to 9.5 kg/cm² (which is regulated by the differential pressure of the start-cut-off pressure switch, meaning that in this case there is a differential set below the cut-off pressure by 1 kg/cm²).

And this high-pressure cut-off pressure switch is set to 10.5 kg/cm² to turn off the burner (set to a difference of 0.2 kg/cm² greater than the highest modulation working pressure variation, or slightly more).

Above the cut-off pressure, it would be advisable to have a maximum cut-off pressure safety switch (with manual reset, but if it is a differential pressure switch and not manually reset, it would be advisable for the differential to be set to the maximum, that is, that the pressure switch does not enable the burner until the pressure drops to a low value, so as to indicate that it has activated the maximum-maximum pressure switch, indicating an abnormality to be checked), which may be about 0.250 Kg/cm2 above the cut-off pressure (10,750 Kg/cm2)

It is evident that the maximum permissible working pressure (design) must be approximately 0.5 kg/cm² above this pressure (the

value that could represent the error in the opening of the safety valves).

Therefore, this maximum permissible working pressure (design) must be at least 11.3 kg/cm².

By regulating at least the first safety valve below this pressure and ensuring that all valves are open, the pressure (under no circumstances) should exceed 11.3 x 1.06 (+6%) = 12 kg/cm². Or 11 x 1.10 (+10%) = 12.5 kg/cm² according to German standards.

In practice, we generally ensure that all valves are open before reaching the maximum permissible working pressure (boiler design).

CALCULATING THE CAPACITY OF SAFETY VALVE

There is more than one way to calculate the required capacity of safety valves, some theoretical and others practical.

The first is based on calculating the heat transfer surfaces and the maximum theoretical heat transfer assigned per unit area for each fuel.

For example, this surface is divided into a heating surface and a surface exposed to combustion, and a specific vaporization capacity is assigned to each.

Example:
In a fire-tube boiler burning fuel oil, 39 kg of steam per m²/hour will be assigned to the surface heated by the gases, and 68.3 kg of steam per m²/hour to the surface heated directly by combustion.

Multiplying each surface area by its respective vaporization capacity and adding the results will give us the minimum capacity required for the safety valves.

To this theoretical calculation, practical-theoretical tests can be added. These consist of forcing combustion and measuring the amount of steam. This can be done in two different ways:

1- By measuring the amount of fuel burned per hour and performing calculations based on the fuel's calorific value, the quality of the generated steam (pressure and temperature), and the boiler's efficiency, the amount of steam produced per hour is calculated.

2- By measuring the amount of feedwater per hour and assuming

that it will all be converted into steam.

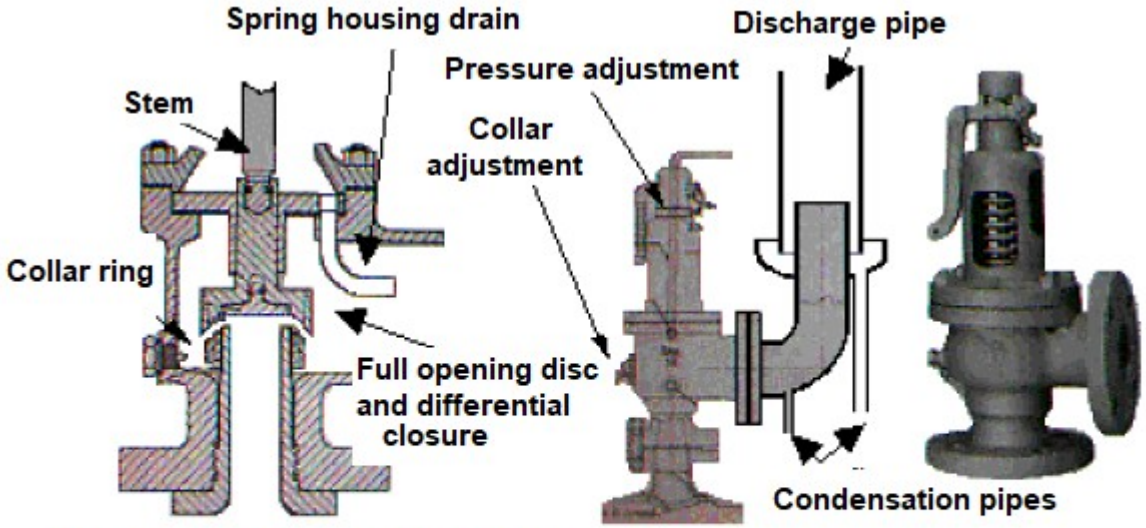
After the valves are installed, it should be verified that, when forced combustion is performed, they do not allow the pressure to rise above the maximum design pressure or "ringing pressure," and that if it does, it does not exceed 6% of that pressure (or 10% if we adhere to German standards).

There are other standards, depending on the country of origin.

The important thing for the stoker is to be certain that the valves are the correct type, size, and material, that they can be tested weekly, if possible, with the lever, and that periodically (at least once a year, with the help of another technician if necessary) they are tested by raising the working pressure to the "ringing" pressure (taking care not to exceed this pressure by more than 6%).

Once the first valve has been tested, proceed to "lock" it and test the second one, which is set to a slightly higher firing pressure than the first.

Remember that in boilers with superheated steam, the superheater safety valve (specially designed for high temperatures) must open before the others and close last, ensuring continuous steam circulation in the superheater (otherwise it will "burn out" due to the high temperature).



Full opening and differential closure depend on the collar adjustment

Safety valve installation

The opening pressure depends on the tension of the spring pushing the stem

The valve discharges should be installed as freely as possible, avoiding elbows or branches, maintaining the correct pipe cross-section, keeping them short, and securely fastened.

It is important to prevent condensation from flowing back towards the valves by directing the drain towards the outlet and installing drains where necessary (almost always against the valve and preventing the drain from falling onto the boiler by using a pipe to divert it away from the casing).

Poor installation of the safety valve discharge piping can limit the capacity needed to prevent the pressure from exceeding the maximum tolerable pressure (6% above the maximum allowable working pressure (design)), which is why actual discharge tests are very important.

C.W.T. Carlos Walter Thomasset (3rd left stand) serving in oil tank R.O.U. Presidente Oribe

Stoker Boiler Handbook 2011, C.W.T. – CHAPTER 12: SAFETY VALVES